

The role of the magnetic resonance imaging safety supervisor: what we should know?

El papel del supervisor de seguridad de imágenes de resonancia magnética: ¿qué debemos saber?

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ABSTARCT: The increasing attention that is given to the protection of health professionals and patients has stimulated researchers and organizations to create alternatives to improve safety practices in health services, including in the Magnetic Resonance Imaging (MRI) environment. However, this theme still needs to be further explored in the MRI field. This paper aims to review the current literature, explore the approach to the MRI Safety Supervisor, to describe the role of the MRI Safety Supervisor and how it could serve as an agent to enhance the safety of health professionals and patients in the MRI environment. To achieve this, a narrative literature review was carried out in the electronic databases: ScienceDirect, PubMed, Scielo and Google Scholar, using as inclusion criteria, articles published in Portuguese and English between the years 2008 to 2019. The articles were filtered according to relevant aspects, such as authorship, title, year of publication, objectives, methodology and main results. Lastly, it considered aspects related to adverse events, international and national regulations on security and safety management in the MRI sector. Nevertheless, in the search for actions that effectively mitigate risks on this modality, it was observed that studies on the MRI Safety Supervisor are scarce, which reinforce the need for further studies on this matter.

KEYS WORDS: Magnetic Resonance. Safety. Management.

INTRODUCTION

A good image are those that are able to differentiate between normal and abnormal anatomical structures, because if there is no difference, it is impracticable to practice a safe report due to the difficulty of detecting possible pathologies. Magnetic resonance imaging (MRI) equipment uses a high magnetic field to produce, reproduce and reconstruct high-resolution images of the human body. (Mazzola et al, 2019). It is noticeable the exceptional difference between the soft tissues in MRI, this only consolidates as another advantage of this technique when compared with other modalities of the diagnosis by image (Westbrook et al., 2013).

When this technique is compared with other types of imaging exams, especially those using ionizing radiation, the acquisition of MRI images is considered safe in relation to the possible biological effects on cells, however there are both associated safety risks: 1) the examination performance and 2) the health environment. (Tobias Gilk & Kanal, 2015). These sa-

fety risks have already been the subject of research, DELFINO et al. (2019) reviewed reports of adverse events in the MR that occurred in the period from January 1, 2008 to December 31, 2017 and observed more than 1,500 incidents, highlighting the thermal, mechanical, projectile and acoustic adverse events.

Due to the effectiveness offered by MRI, in its high capacity to differentiate anatomical and functional structures, the search for this technical application grows considerably (Ferreira & Nacif, 2011). Data from CNES (National Registry of Health Facilities) show an increase in the number of equipment for the diagnosis of medical pathologies. In particular, there is a considerable increase in the northeast of Brazil, which had 207 equipment installed in 2012, already in 2019 this number rose to 476 (CNES, 2019).

Despite of this growth, the care should be taken. The website Auntminnie.com published an article about an MRI accident that occurred in Swe-

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den in April 2019. The famous MRI researcher, Dr. Torkel Brismar, stated that, "There are so many MRI units now, sooner or later one of those almost unlikely things will happen".

Therefore, it is expected that the RM community be aware of intensifying the safety culture demand, as well as thinking about the professional able for developing, practicing and updating specific safety programs. The aim of this review is to identify the role of the magnetic resonance imaging safety supervisor to avoid and reduce adverse events in MRI services.

MATERIAL AND METHOD

This research was carried out as a narrative review of the literature. For the development of this work, the databases: ScienDirect, PubMed, Scielo and Google Scholar, were used and the keywords: Magnetic Resonance Security, good MR practices, Safe MR Practices were selected to undertake the search. The sample included articles published between 2008 and 2019, published in English and Portuguese, available as a fulltext.

In addition, the search was conducted according to standards of the following international bodies: American College of Radiology (ACR), The Emergency Care Research Institute (ECRI), Institute for Magnetic Resonance Safety, Education, and Research (IMRSER), and the Food and Drug Administration (FDA), Medicines and Healthcare Products Regulatory Agency (MHRA), International Society for Medical Magnetic Resonance Imaging (ISMRM), Society for MR Radiographers & Technologists (SMRT). In total 21 scientific articles were founded.

Studies in editorial format, news, professional comments, studies without an abstract and articles published in languages other than Portuguese and English were excluded, 9 in total. Therefore, 12 scientific papers were selected to construct this review.

LITERATURE REVIEW

Patient and team safety in MR

In the National Self-Assessment Report on Patient Safety Practices in Health Services - 2019

(Anvisa), patient safety means "the reduction, to an acceptable minimum, of the risk of unnecessary harm associated with health care". In order to pay attention to the problem of patient safety, the World Health Organization (WHO) created the World Alliance for Patient Safety, with the mission of coordinating, disseminating and accelerating improvements for patient safety (Vasconcelos, 2018). Patient safety is a continuous work of awareness that health professionals must practice in the clinical / hospital environment, in order to keep the patient from possible adverse reactions or even accidents that may become irreversible (Marchon; Mendes Junior, 2014).

In the MR environment, patients, professionals and the general public are vulnerable to the existing risks. However, it is important to intensify concepts about security policies that give the minimum conditions of comfort, safety and efficiency to all individuals during the service (Vasconcelos).

Adverse events can cause injury to patients and increase their length of stay, mortality and hospital cost. In addition, health professionals who are under the responsibility of the patient who suffered the adverse event, can go through a difficult time, as they will be under emotional stress, in conflict with ethical principles and in view of the possible legal punishments to which they are exposed. (Duarte *et al.*, 2014).

Adverse events in Rm's environment

Failures in the safety steps in the MR environment can result in adverse events such as thermal, mechanical, projectile and acoustic incidents. In addition, when the equipment is operated in the wrong way, it can generate an incorrect diagnosis, with the possibility of causing irreparable damage. (Delfino *et al.*, 2019) An accident that occurred in 2001 in the United States, is still widely publicized due to the tragic outcome, in which a 6-year-old child was hit by an oxygen cylinder that was taken into the examination room, and the object became a projectile when it was attracted by the strong magnetic field, reaching the head of the child who unfortunately died. (PARRA *et al.*, 2018) More recently in January 2018, a man in the city of Mumbai, India, died after being pressed between an oxygen cylinder and MRI equipment (Jormada & Medeiros, 2015).

In the period between 2008 and 2017, more than 1,500 adverse events were identified and reviewed, considering the thermal ones representing 59% of the analyzed reports, the mechanical events (11%), by projectile (9%) and acoustic (6%). (Delfino *et al.*, 2019).

Some articles and news have already been published reporting MR accidents, as shown in the Table I:

MRI safety culture

Many accidents can be avoided through carefully structured supervision accompanied by the implementation of strict guidelines. (Cross *et al.*, 2018). In order to create a culture of safety in magnetic resonance imaging, it is necessary to have a thorough knowledge of MRI equipment, from the principles of image formation to the protocols used for this purpose (Crisp & Dawdy, 2017).

The safety recommendations need to be at the highest of priorities, this confirms the need to have a professional responsible for the day-to-day implementation of the safety culture, to inspect, guide and offer continuous training to all professionals involved in the acquisition of magnetic resonance images (Jormada & Medeiros). Increasingly, the number of accidents in the MR is increasing. In the search for solutions to minimize these accidents as little as possible, it is necessary to invest in safety training at RM for technologists, radiologists and other professionals involved with this technology (Shellock, 2020).

It is worth mentioning that there are no specific Brazilian norms about the implantation of a professional in the magnetic resonance sector designed to guarantee security policies (Ferreira & Nacif, 2011). International entities such as the American College of Radiology (ACR), The Emergency Care Research Institute (ECRI), Institute for Mag-

Table I:

Author	Year	Kind of accident	Observations
Jusbrasil.	2012	One patient suffered a third-degree burn on his calf during knee MRI.	Generated an indemnity of R\$: 15.000 and the technician was fired.
TV Brasil da Empresa Brasil de comunicação - EBC.	2013	Three people died after MRI scans of the brain.	The health secretary of the state of Sao Paulo ordered the interruption of the service for almost two months.
JORNADA RIBEIRO, 2015.	2014	In India, an oxygen cylinder that pressed him against the gantry hit an operator.	Resulted in wounds.
JORMADA RIBEIRO, 2015.	2014	In New Zealand, an operator was hit by a knife in the patient's possession.	Resulted in wounds.
JORMADA RIBEIRO, 2015.	2014	In India, where a patient was injured when a stretcher was introduced into the room.	
MAZZOLA, Alessandro A <i>et al.</i>	2019	After starting an MRI scan of the skull, a pocket knife that remained in the patient's pocket was attracted to the magnet.	It ended up shocking his eye and causing a fracture in the orbit. The institution did not routinely change patients' clothes as a routine.
MAZZOLA, Alessandro A <i>et al.</i>	2019	Weapons of military policemen attracted by the magnet.	After a suspected invasion of a clinic in Florianopolis, Santa Catarina, cops entered the examination room with guns drawn.
A untminnie.com	2019	In Sweden, a nurse was sucked into the strong magnetic field, she was wearing a vest that contained fine particles of iron ore.	On impact, she was unconscious and injured, the guard used a knife to cut the strap of the vest.

netic Resonance Safety, Education, and Research (IMRSER) and the Food and Drug Administration (FDA), solidly establish the standard of care of how to practice security. (Jormada & Medeiros). Therefore, these safe practice guidelines can be used by countries that do not have specific legislation (Ferreira & Nacif).

It is reality that hospitals bring together a multiprofessional team with the aim of creating a safety culture in the MR to educate all employees about the risks and dangers associated with MR. There are several resources created, ranging from routine training to the use of technology to create tools that can help intensify the safety plan (CRISP; DAWDY, 2017).

International RM security recommendations

Scientific and medical societies represented by the European Federation of Organizations for Medical Physics (EFOMP), European Federation of Radiographer Societies (EFRS), European Magnetic Resonance Society in Medicine and Biology (ESMRMB), European Society of Radiology (ESR), European Magnetic Resonance Society in Medicine and Biology (ESMRMB), Society for MR Radiographers & Technologists (SMRT), American Magnetic Resonance Imaging Security Council (ABMRS) and the Cardiovascular Magnetic Resonance Society (SCMR), developed and approved by consensus, an article reporting the recommended responsibilities for managing security in the RM. Several societies around the world approved the document, making it a big step towards international acceptance. The objective was to contribute to the implementation of an appropriate institutional structure to ensure safety in MR (Calamante *et al.*, 2016).

In view of the development of specific regulations, it is worth highlighting ECRI's guidelines on inspection, emphasizing the need to officially create the safety position or responsible for ensuring that procedures or regulations are applied and updated (Jormada & Medeiros).

In the search for guarantees of continuity and sustainability of the procedures or regulations applied, it is necessary to delegate this task force by creating a new position of security supervisor dedicated exclusively to RM. Changes in the safety culture in RM, it is necessary to raise awareness of all personnel who are directly or indirectly involved in the RM sector (Parra *et al.*, 2018).

In addition to recommending, the American Board of Magnetic Resonance Safety (ABMRS) provides credentials for MR Security Supervisor, they require certification and qualification. Certification is carried out by means the application of the formal exam corresponding to that specific title / position. The certification is valid for 10 years, with the obligation to renew after the end of this period. Upon satisfactory completion of this exam, the professional will become a member of ABMRS and will be certified to use the title of Magnetic Resonance Safety Supervisor (MRSS).

The role of the MRI supervisor

According to CALAMANTE *et al.* (2016), the role of the MRSS is often played by the Technologist in Radiology and his responsibilities include:

1. Be readily accessible and available (for example, for RM system operators) whenever the RM service is operationally operational.
2. Ensure the application of adequate strategies and procedures for the daily safety of the MR.
3. Develop, document and introduce, in conjunction with and under the authority of the physician responsible for the MR environment, safe work procedures.
4. Ensure that safety procedures, work instructions, emergency procedures and operational instructions are made available to everyone involved in the RM.
5. Ensure that appropriate measures to minimize health risks arising from the use or exposure to MRI equipment, in accordance with the instructions of the physician responsible for the MRI, are implemented and monitored. An example used to minimize risks is to have well-defined access control for so-called zones, which are areas divided between I, II, III and IV. In zone I, it is an external area allowed for any circular person, in zone II, it is the area intended for reception (main entrance of the RM service) and changing rooms, in this place it is already recommended that all people be screened in order to avoid accidents. Zone III is the area directly adjacent to the exam room that should only be released for people who are properly equipped with safe tracking and finally, zone IV, which is the room that performs MRI exams, where everyone, both staff and Patients must be accompanied by a highly trained professional, usually the radiology techno-

- logist. (Ferreira & Nacif).
6. Manage the risks presented by the MRI equipment and monitor the safety strategies.
 7. Ensure that all department heads and members of the medical team responsible for personnel involved in the MR system are informed of formal training procedures.
 8. Ensure that doctors, technicians, nurses and all other groups of employees (including auxiliary workers) who may be exposed to the RM environment are adequately trained, regularly, on safety requirements and updated as necessary. Some professionals in nursing, transportation, cleaning, maintenance, and even anesthesiologists, are inclined to forget key safety elements in MRI, because sometimes they do not have enough training to deal with the day-to-day operation on RM, therefore, as they are necessary services, they need to be trained following continuous education (PARRA *et al.* 2018).
 9. Maintain records of personnel who have been properly trained in safety requirements. Due to employee turnover, attention needs to be addressed to create an access control system according to member function who could have access to the RM area, and consequently control this list by removing members who may not have access. (PARRA *et al.*)
 10. Consult the physician responsible for the MR sector as often as necessary regarding the safety of the MR.
 11. Report to the physician responsible for the MRI area in a timely manner about any problems related to MRI safety.
 12. Ensure that there is a clear policy for the purchase, testing of all equipment that will be taken to critical areas related to MRI.
 13. Ensure that safety training for MRI is in accordance with safety policies and in cooperation with the physician responsible for the MRI sector.
 14. Provide safety advice on the selection, purchase and installation of MRI-related equipment (in consultation with a physician responsible for the MRI sector, if necessary).
 15. Provide safety advice on modifying MRI protocols (in consultation with a physician responsible for the MRI sector, if necessary).
 16. Maintain regular contact with other groups or committees, responsible for the safety and well-being of personnel, as well as ethics committees and other safety committees from other sectors.

DISCUSSION

The acquisition of magnetic resonance images is considered safe, mainly because of its physical principles of image formation that do not need ionizing radiation, however, the risks are realities in this environment, which can even lead to the death of people (Mazzola *et al.*, 2019). All health facilities that have an MRI modality should adopt MRI security policies and procedures, as well as review and update all procedures frequently to ensure that any and all adverse events will not happen (Kanal *et al.* 2002).

Several accidents have already been recorded around the world, which justifies institutions to create and apply fundamentals of safety in the MR based on recommendations created by globally recognized institutions. In addition, the absence of the necessary resources to guarantee safety, the probabilities of accidents increase and possible negative impacts may become irreversible to society as a whole (Mazzola *et al.*).

Although the MRI examination is considered a safe examination, as there are no proven biological effects on the cells. The examination is complex and requires attention since accidents can occur related to a failure in this process. In 2013, shortly after the MRI exams, three patients died in a hospital in the city of Campinas in São Paulo. After almost two months of interdiction of the service by the health surveillance, a publication was made in the Official Gazeta of Campinas deinterditing the service (OFFICIAL DIARY OF CAMPINAS, nº 10,591, page 21). Events like these must be investigated and analyzed both from the point of view of human losses, which are irreparable, and from health care (ANVISA, 2013). In 2013, the portal R7.com reported that after the deaths in Campinas, patients started to avoid magnetic resonance imaging, which generates evident losses due to the decrease in the performance of MRI exams.

Failures due to the lack of proper training can result in accidents, such as what happened in 2018 in India, where a person entered in the MR room with an oxygen cylinder, was attracted by the strong magnetic field, which resulted in his death. It should be noted that there was authorization from the professional for the companion to enter the examination room (Mazzola *et al.*).

It is possible that in Brazil accidents have occurred that have not been computed and reported. The Magnetic Resonance Society in Medicine (ISMARM) recommends that it is essential to notify and report incidents, as well as to identify the causes. This could allow to improve work practices, policies and procedures. It is even possible to carry out these notifications on specific channels already adopted by some societies in several countries, which may be an object of study and later on as a source of information to contribute to the entire RM community, thus reducing the risks of similar incidents.

The increase in the amount of equipment at MRI in health establishments around the world, is directly proportional to the increase in the number of MRI imaging exams, according to data from ANS (Agencia reguladora de planos de saúde do Brasil, 2018). In Brazil, 2018, more than 3 million exams per MRI were performed, representing a total 1 billion and one hundred million reais. According to RDC 330/2019 IN 59, the discussion on MR security is still ongoing, however, in the state of Minas Gerais there is a guideline RESOLUTION SES/ MG No. 6234, of May 10, 2018, which disclosed the Technical Regulation that establishes the basic protection and safety requirements in MRI, highlighting the demand for the safety and quality requirements in RM. This demand is expected to expand along of the country so that the MRI safety culture provide the health of patients and professionals involved.

An effective continuing education program developed, practiced and reviewed by an MRSS, makes it possible that adverse events such as those presented in this work could be avoided. In the case of the weapons of police officers who were attracted to the magnet, for example, the insertion of a local police department in the effective continuing education program helps everyone to understand what procedure can be taken. It is possible to use actions similar to those used in emergency case with the fire brigade. The website firehouse.com, published about the fire brigade's response to emergencies involving MRI, where specific tactics can only proceed if there is involvement and determination of a person responsible for the magnetic resonance unit.

Final considerations

This work provided an explanation that involves the need to create a safety management for

patients and professionals in the MRI sector, due to visible growth of this modality as a means of diagnostic imaging, which indicates the possibility of the growth of countless possible accidents. It was also possible to observe that in view of the challenges on this safety theme for patients and professionals in the MRI, the creation of the position of MRI Safety Supervisor is an effective alternative for enhancing the MRI safety.

Therefore, it is expected that this work will contribute to the MRI community to expand its studies in search of understanding about the inclusion of a professional trained exclusively to practice safety in the routine of the MRI service.

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RESUMEN: The increasing attention that is given to the protection of health professionals and patients has stimulated researchers and organizations to create alternatives to improve safety practices in health services, including in the Magnetic Resonance Imaging (MRI) environment. However, this theme still needs to be further explored in the MRI field. This paper aims to review the current literature, explore the approach to the MRI Safety Supervisor, to describe the role of the MRI Safety Supervisor and how it could serve as an agent to enhance the safety of health professionals and patients in the MRI environment. To achieve this, a narrative literature review was carried out in the electronic databases: ScienceDirect, PubMed, Scielo and Google Scholar, using as inclusion criteria, articles published in Portuguese and English between the years 2008 to 2019. The articles were filtered according to relevant aspects, such as authorship, title, year of publication, objectives, methodology and main results. Lastly, it considered aspects related to adverse events, international and national regulations on security and safety management in the MRI sector. Nevertheless, in the search for actions that effectively mitigate risks on this modality, it was observed that studies on the MRI Safety Supervisor are scarce, which reinforce the need for further studies on this matter.

KEYS WORDS: Magnetic Resonance. Safety. Management.

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